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THE ZUNI SALT LAKE¹

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Forty-two miles south-by-east from the Pueblo of Zuñi there is a small salt lake, affording a local supply of salt for the Indians and others. It occupies a portion of the bottom of a remarkable steep-sided, circular depression about a mile in diameter, near the center of which rise two fresh volcanic cinder cones. The depression appears not to be a volcanic crater, but has walls of Cretaceous sandstone capped by a lava sheet and deposits of volcanic ejecta. One of the cinder cones rising near the center of the depression has a deep crater containing a pool of salt water at the lake-level.

This salt lake has been known to the Zuñi Indians for a very long period, and for a half-century or more to Mexicans and a few travelers. The first account of its geologic relations was a brief note by E. E. Howell, of the Wheeler Survey,² who visited the locality in 1873. This observer noted the sandstone walls capped in part by lava flows, and the cinder cone with deep crater, but offered no suggestion as to their origin. Professor C. L. Herrick visited the salt lake in December, 1899, and afforded some further descriptive details.³

¹ Read to the Geological Society of America, December 28, 1904, and published by permission of the director of the U. S. Geological Survey.

² George M. Wheeler, "U. S. Geographical Surveys West of 100th Meridian," *Reports*, Vol. III, pp. 538, 539.

³ *American Geologist*, Vol. XXV.

He suggested that the depression might be due to the solution of the salt in underlying strata, causing the depressed area to subside.

The lake is shallow, and its waters are saturated with common salt, containing 26 per cent. in December, 1899, according to Professor C. L. Herrick. As the natural evaporation progresses, salt

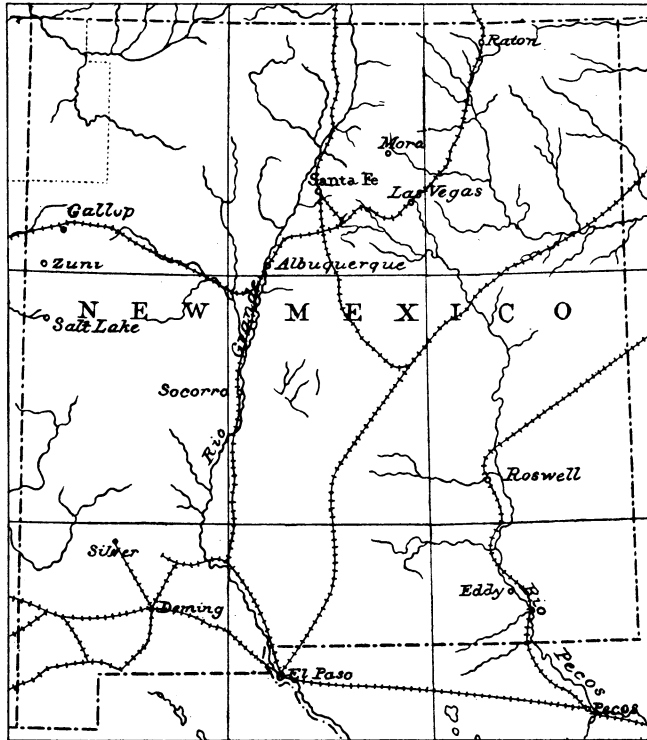


FIG. 1.—Map of New Mexico, showing the location of the salt lake south of Zuni.

is constantly deposited, and doubtless a large amount has accumulated. On the north shore of the lake there is a small settlement of Mexicans, who gather the salt for shipment, and many persons make special trips to the lake, often from long distances, to collect a load of the salt. The quality is excellent and the supply large. Only the crudest methods are employed for gathering the freshly deposited salt in the shallow waters near the north shore of the lake.

The Indians have utilized this source of salt for many centuries and regard the lake with great veneration.

There is a large amount of salt in the lake and springs. An average of about three tons a day is produced by very crude methods; it is valued at from \$2 to \$2.50 a ton. This industry sustains the small settlement of Mexicans.

The origin of the salt is believed to be in springs which rise under the water near the south end of the lake. If the water from these is not saturated with salt, the percentage increases by the great evaporation in this arid region. Undoubtedly it is derived from the underlying Red Beds, which have the relations shown in the cross-sections. These Red Beds outcrop at no great distance, and yield salt springs at some points. A small amount of fresh water flows into the lake, partly from a small spring on the east shore, which flows constantly, and partly from scanty rains falling directly into the depression, or running into it from a small drainage area lying mainly on the high slopes south. Although no deep borings have been made, the depression appears to contain a salt deposit of considerable thickness, mixed with small amounts of mud washed from the surrounding slopes, and dust carried by the wind. Apparently the lake occupied the entire floor of the depression at one time, but, by evaporation and the deposition of mud, it has greatly diminished in size; doubtless the lake has been crowded over to the north side of the depression because the greater amount of detritus is deposited on the south side.

In the map and cross-sections of Fig. 2 are shown the principal features of the salt lake depression, and the photographs reproduced in Figs. 3-5 show the lake from three points of view.

The depression is in a plain sloping gently northward on the south side of the Carrizo Valley. A short distance to the south rises a line of cliffs of Cretaceous sandstones, in part capped by lava, while there is a corresponding ridge several miles north on the opposite side of the valley. The floor of the valley is Cretaceous sandstone, overlain in places by lava flows, one of which forms part of the upper wall of the northern, eastern, and southeastern sides of the depression. All about the margin of the depression there is a widespread mantle of fragmental material, mostly volcanic, which thickens toward

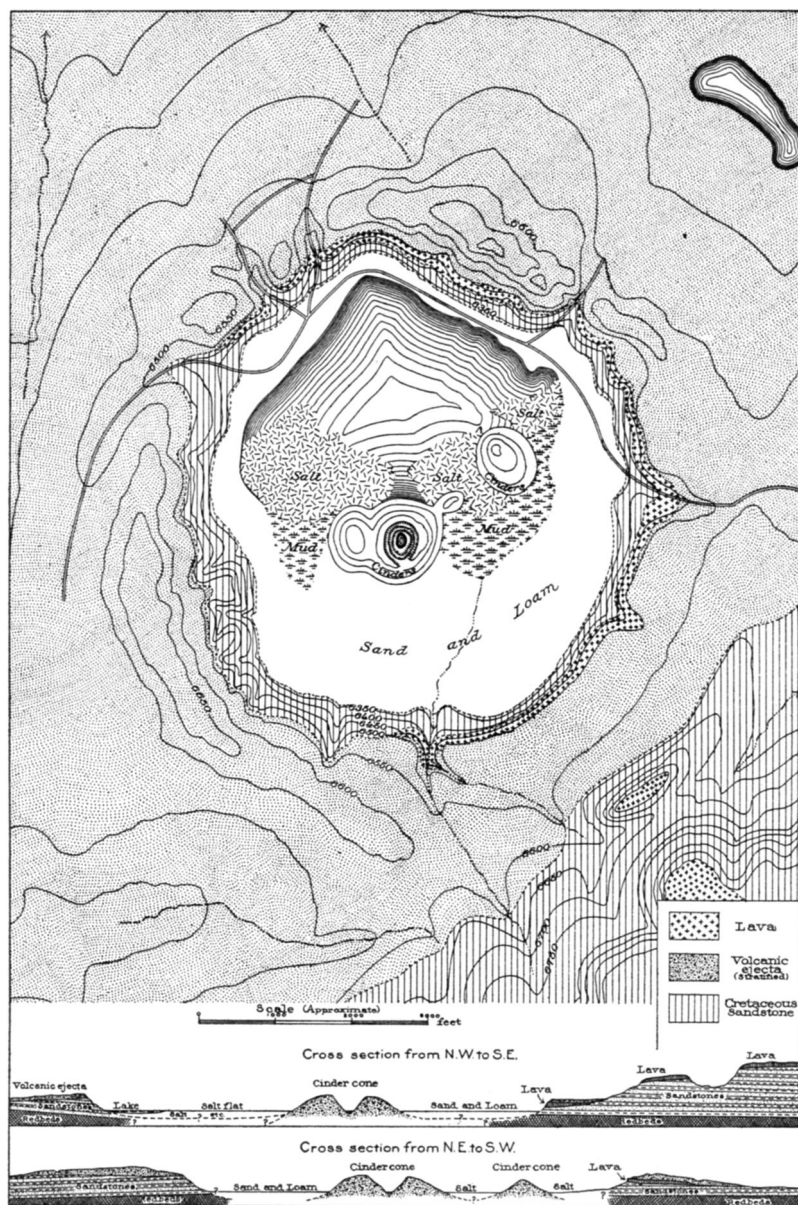


FIG. 2.—Sketch map and sections of Zuñi salt lake, New Mexico, by N. H. Darton. Contour interval 50 feet.

the rim. It attains a thickness of over 100 feet on the north and southwest portions of the rim, where it rises in a ridge of considerable prominence. The material is mostly stratified, fine-grained, and in part cross-bedded. It consists mainly of scoria, but includes fragments of various kinds of sedimentary rocks, including Carboniferous (Aubrey) limestones with characteristic fossils.¹

The view from the rim of the depression is impressive. The ground sinks for 150 feet or more in a circular area a mile in diameter, with flat bottom in part occupied by the lake and in part by the glistening salt and mud flats. The two volcanic cones in the center of the basin are prominent features, rising steeply to an elevation of nearly 150 feet above the lake. The larger cone has a deep crater in its summit, which contains a circular pool, about 150 feet in diameter, at the lake level. The water of this pool is very salt, but several per cent. less so than that in the main lake. The cone is nearly circular, except on its western side, where it merges into the remains of a slightly older volcanic mass. The second cone is a short distance northeast, rising steeply out of the mud flat at the southeastern margin of the lake. It has no crater, is smaller, and appears to be somewhat older than the other cone. Both cones consist of scoria and other volcanic ejecta, and they are similar to the cones in the numerous lava fields of New Mexico. Walls of Cretaceous sandstone encircle the depression, which to the north, east, and southeast are capped by a sheet of lava from 30 to 50 feet thick. To the west and southwest the sandstone wall rises in cliffs and rocky slopes about 150 feet above the bottom of the depression, and is capped by rolling hills composed of beds of fragmental volcanic materials, while to the north, east, and south it rises from 60 to 70 feet to the base of the lava sheet. The lava sheet which caps the sandstone walls on the southeast, north, and east sides of the depression is an ordinary sheet of "malpais" or black lava, which appears to be older than the cinder cone with the crater in it.

¹ These fossils were determined by Dr. George H. Girty as follows:

<i>Lophophyllum</i> sp.	<i>Phillipsia</i> sp.
<i>Productus ivesi</i> .	<i>Chonetes</i> n. sp.
<i>Productus mexicanus</i> ?	<i>Productus occidentalis</i> .
<i>Productus</i> sp.	<i>Seminula mexicana</i> .
<i>Bakewellia</i> ? sp.	<i>Schizodus</i> sp.
<i>Laeviadentalium cana</i> .	<i>Euomphalus</i> sp.

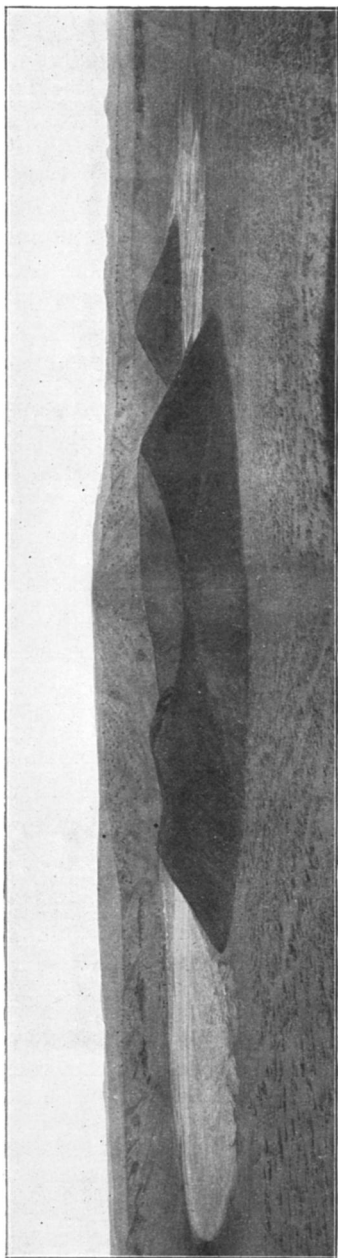


FIG. 3.—Looking north across Zuni salt lake, showing large cinder cone with crater. Ridge of scoria in middle-ground, sandstone plateau in distance.

The origin and history of the depression are an interesting problem. From the continuity of its sandstone walls, it clearly is not a portion of an old valley dammed by a lava stream, and it presents none of the ordinary features of a crater. In some respects it is comparable to "Coon Butte," a great depression west of Winslow in eastern Arizona, which, Mr. Gilbert has shown, is due to explosion, but although there is a ring of ejected rocks around the margin of the Zuni depression, the relative bulk is small and the materials are waterlaid. The most reasonable hypothesis appears to be that the depression is due to the sinking of its bottom, and the fact that there are salt springs and the area is underlain by salt-bearing beds are significant in this connection. It seems possible that a salt bed has been dissolved, possibly by hot water issuing from a volcanic vent, and the depressed area has dropped or faulted several hundred feet. Several instances are known of the development of deep crater-like depressions due to underground solution of salt and

gypsum beds, and sinking of overlying strata, notably at the "Salt Lake" near Meade, Kansas, and the "Devil's Hole" near the River Virgin in southwestern Utah. At the Zuñi salt lake, however, volcanic phenomena appear to be connected with the development of the depression, especially the presence of cinder cones in the center and the mantle of stratified ejecta encircling its rim. Probably the lava sheet capping the east rim is older than the

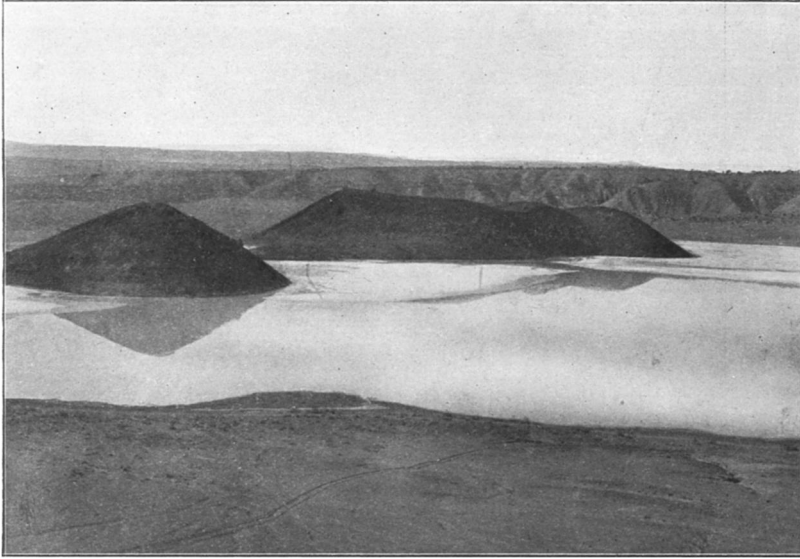


FIG. 4.—Looking southwest across Zuñi salt lake. Large cinder cone to the right, small cinder cone to the left, rising out of salt fields. South rim of depression in middle-ground, plateau of Cretaceous sandstone in distance.

depression, and perhaps did not come from the same orifice as the cinder cones. In the plateau region of New Mexico such cones are usually built following an outflow of lava and mark the last stage of the eruption. The cones in the depression appear to be very fresh and recent, and while they may be connected with a lava flow under the floor of the depression, there is no evidence on this point. The following hypothesis as to the origin and history of the Zuñi salt lake depression lacks positive evidence along several lines, but it is the most plausible one suggested.

Originally the area was a plain sloping gently to the Carrizo Creek and on this plain a sheet of lava was ejected, possibly from a vent marked later by the cinder cones in the depression. Following the



FIG. 5.—Looking into the crater in the larger cinder cone; showing pool of salt water which is at lake level.

lava flow there was a great ejection of hot water from a central vent, which dissolved a thick mass of salt, and brought to the surface and spread in all directions a large amount of fine scoria and rock frag-

ments, including the fossiliferous limestone. By this means a great, low mound of irregularly stratified material was built, extending from the edge of the depression. Consequent upon this eruption, a circular depressed area, a mile in diameter, subsided into the space made by the solution of salt and in smaller measure by the ejection of various rocks.

A much less probable hypothesis is that not only the lava sheet was extruded, but the sheet of volcanic ejecta was deposited and the cones built up *prior* to the subsidence. If this was the case, there is under the floor of the depression a sheet of lava overlain by a thick mass of volcanic ejecta, faulted down from the level of the lava and ejecta deposits on the rim. After the subsidence a new eruption gave rise to the cinder cones, at least to the one with the crater, for the other cone northeast may represent the stock of an earlier eruption. Water has continued to rise in the bottom of the depression, now only in small volume, but carrying much salt. Probably the lake occupied the entire bottom of the depression at one time, but evaporation and sediments especially those deposited by the torrential water courses on the south side, have evidently diminished the water area.